



US009199355B2

(12) **United States Patent**  
**Lee et al.**

(10) **Patent No.:** **US 9,199,355 B2**  
(45) **Date of Patent:** **Dec. 1, 2015**

(54) **APPARATUS FOR GRINDING A SUBSTRATE  
AND METHOD OF USING THE SAME**

USPC ..... 451/5, 6, 10, 11, 21, 41, 333, 335, 339  
See application file for complete search history.

(71) Applicant: **Samsung Display Co., Ltd.**, Yongin,  
Gyeonggi-do (KR)

(56) **References Cited**

(72) Inventors: **Inho Lee**, Suwon-si (KR); **Hwankyeong Jeong**, Asan-si (KR); **Jinwoo Kim**, Suwon-si (KR); **Goangyoung Park**, Hwaseong-si (KR); **Sanghoon Back**, Asan-si (KR); **Eehyun An**, Hwaseong-si (KR)

U.S. PATENT DOCUMENTS

3,791,084	A *	2/1974	Kakumu et al.	451/21
4,020,598	A *	5/1977	Harmant	451/124
4,528,743	A *	7/1985	Bleich	483/10
4,654,953	A *	4/1987	Hobbs	483/33
5,119,600	A *	6/1992	Chikatsune et al.	451/21

(Continued)

(73) Assignee: **SAMSUNG DISPLAY CO., LTD.**,  
Yongin, Gyeonggi-Do (KR)

FOREIGN PATENT DOCUMENTS

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 267 days.

JP	2002-370145	12/2002
JP	2008-023677	2/2008

(Continued)

*Primary Examiner* — Eileen Morgan

(21) Appl. No.: **13/728,671**

(74) *Attorney, Agent, or Firm* — F. Chau & Associates, LLC

(22) Filed: **Dec. 27, 2012**

(65) **Prior Publication Data**

US 2013/0316618 A1 Nov. 28, 2013

(30) **Foreign Application Priority Data**

May 22, 2012 (KR) ..... 10-2012-0054443

(51) **Int. Cl.**  
**B24B 49/12** (2006.01)  
**B24B 41/00** (2006.01)  
**B24B 9/10** (2006.01)

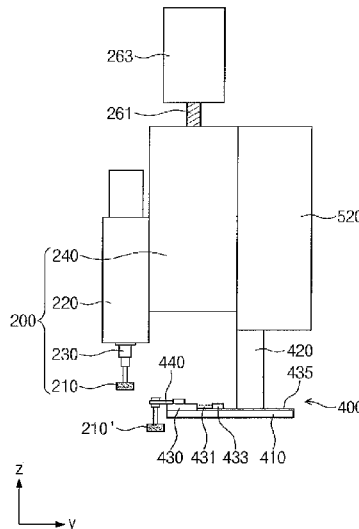
(52) **U.S. Cl.**  
CPC . **B24B 49/12** (2013.01); **B24B 9/10** (2013.01);  
**B24B 41/00** (2013.01)

(58) **Field of Classification Search**  
CPC ..... B24B 49/00; B24B 49/12; B24B 41/00;  
B24B 41/005; B24B 37/345; B24B 9/10

(57) **ABSTRACT**

An apparatus for grinding a substrate includes a stage part configured to support a substrate thereon, a grinding part, a camera part, a replacing part and a control unit. The grinding part includes a grinding wheel configured to grind an edge of the substrate. The camera part is configured to take a picture of the grinding wheel, analyze the picture of the grinding wheel and generate information about the grinding wheel. The replacing part includes a spare grinding wheel and is configured provide the spare grinding wheel to the grinding part or pick up the grinding wheel from the grinding part. The control unit is configured to receive the grinding wheel information from the camera part and offset compensate a position of the grinding wheel on the basis of the grinding wheel information or communicate with the replacing part to replace the grinding wheel on the basis of the grinding wheel information.

**22 Claims, 8 Drawing Sheets**



(56)	<b>References Cited</b>			JP	2011-224668	11/2011
	U.S. PATENT DOCUMENTS			KR	1020040028389	4/2004
				KR	1020050082638	8/2005
				KR	1020050118558	12/2005
	5,220,749	A *	6/1993 Youden et al. ....	KR	1020060078166	7/2006
	5,458,527	A *	10/1995 Kondo et al. ....	KR	1020060095754	9/2006
	5,586,928	A *	12/1996 Wiand et al. ....	KR	1020070087820	8/2007
	5,697,834	A *	12/1997 Heumann et al. ....	KR	1020070109302	11/2007
	6,315,799	B1 *	11/2001 Toniolo ....	KR	1020070121205	12/2007
	6,325,704	B1	12/2001 Brown et al.	KR	1020070121434	12/2007
	6,428,390	B1	8/2002 Clark et al.	KR	1020080106680	12/2008
	6,949,005	B1 *	9/2005 Larsen et al. ....	KR	1020090021769	3/2009
	7,001,249	B1	2/2006 Pride et al.	KR	1020100018202	2/2010
	7,131,893	B2	11/2006 Shin	KR	1020100048732	5/2010
	7,153,190	B2 *	12/2006 Mavro-Michaelis ....	KR	1020100132131	12/2010
	7,179,155	B2	2/2007 Shin et al.	KR	101030084	4/2011
	7,335,091	B2 *	2/2008 Burgess ....	KR	1020110044120	4/2011
	2006/0035565	A1 *	2/2006 Mavro-Michaelis ....	KR	1020110072030	6/2011
	2009/0233529	A1	9/2009 Ueda	KR	1020110111823	10/2011
	2011/0021116	A1	1/2011 Brown et al.	KR	1020110119133	11/2011
				KR	20110139188	12/2011
				FOREIGN PATENT DOCUMENTS		
JP	2009-028870	2/2009		* cited by examiner		

Fig. 1

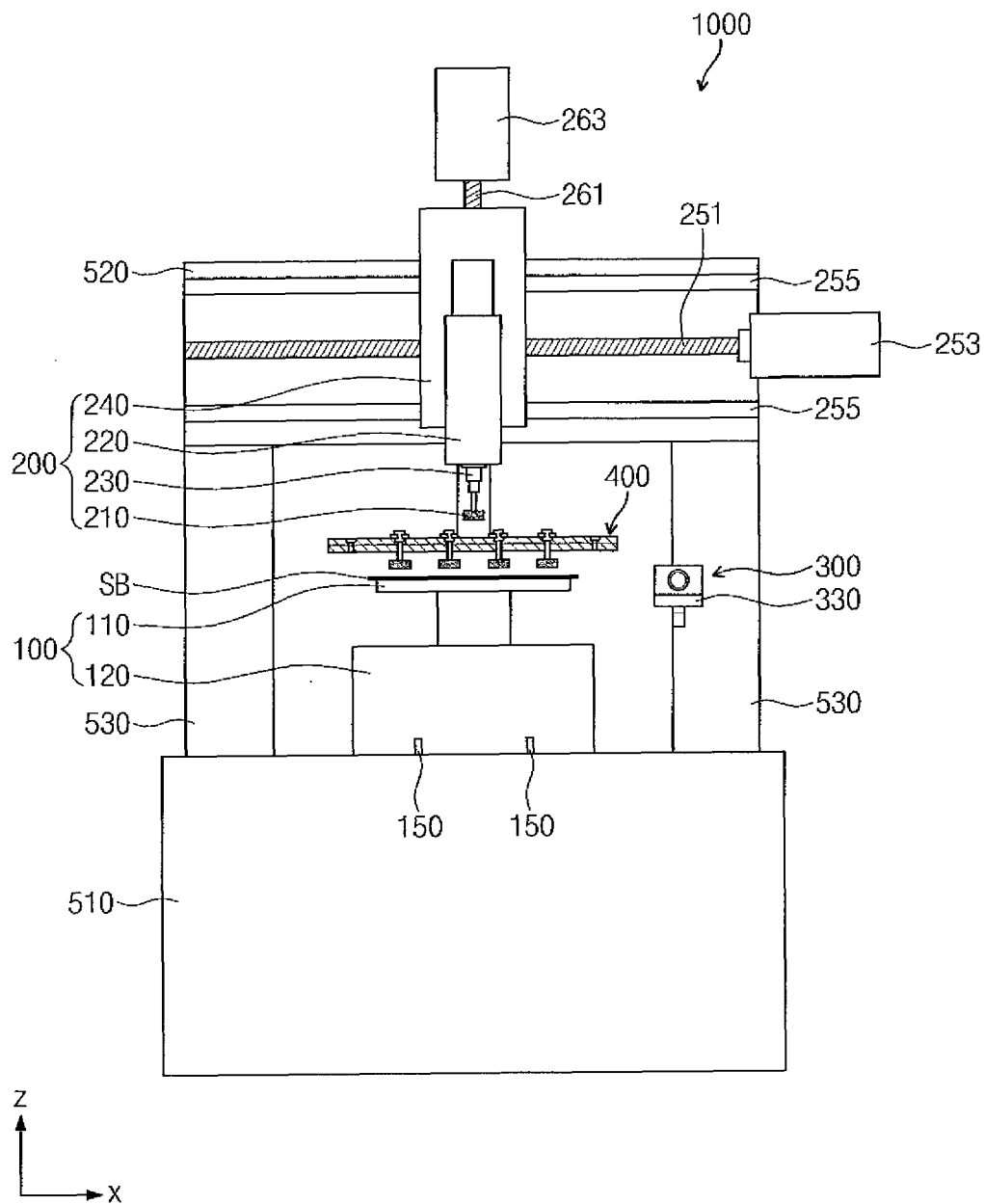


Fig. 2

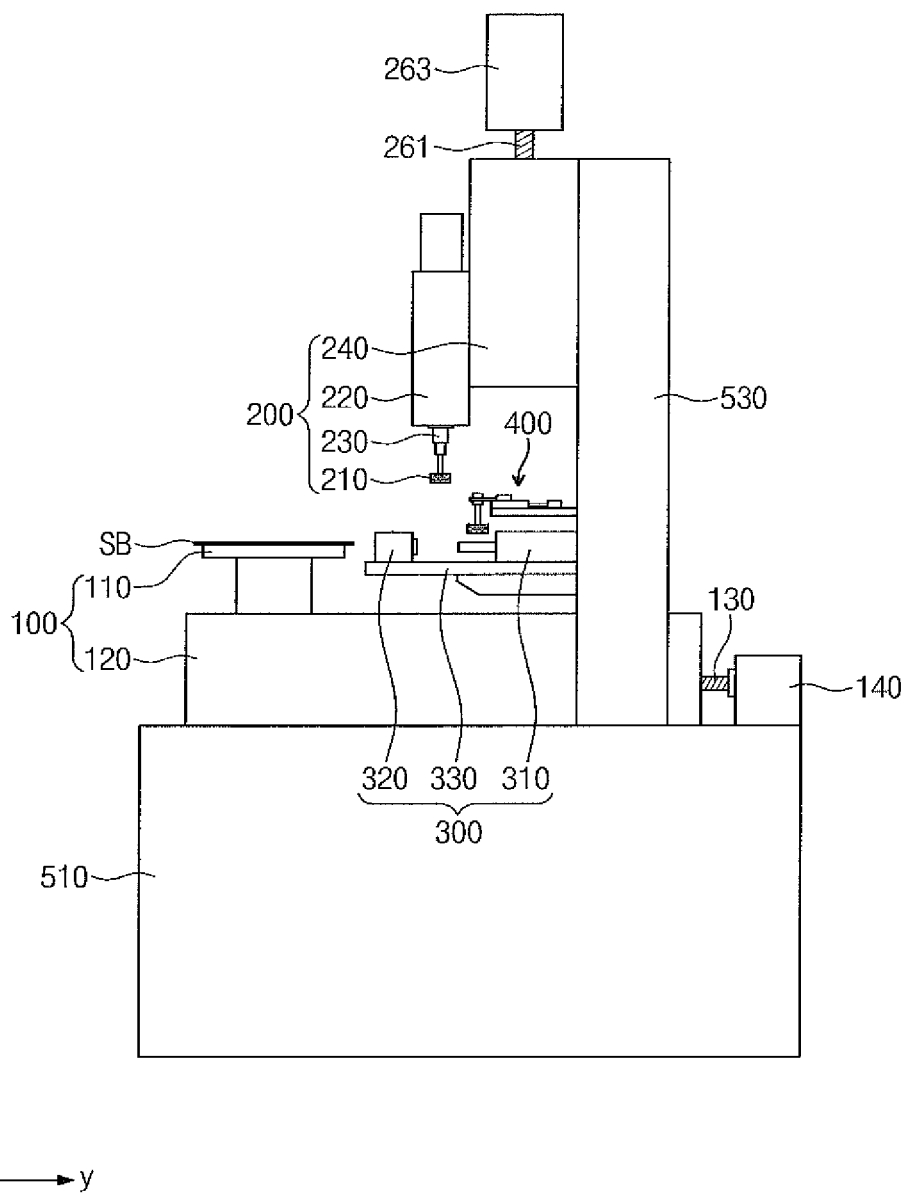


Fig. 3

210

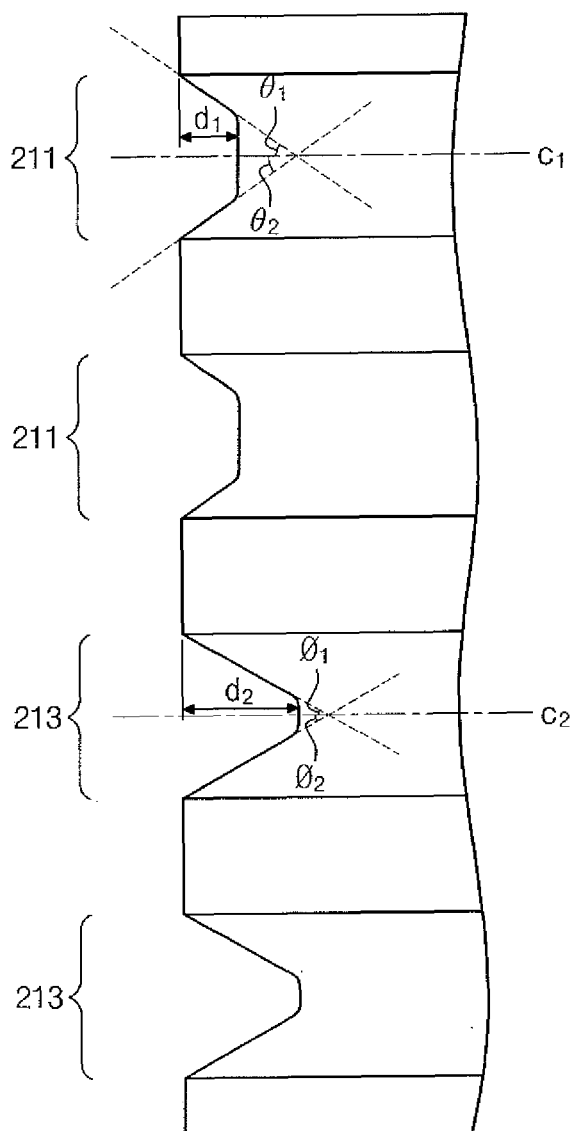


Fig. 4

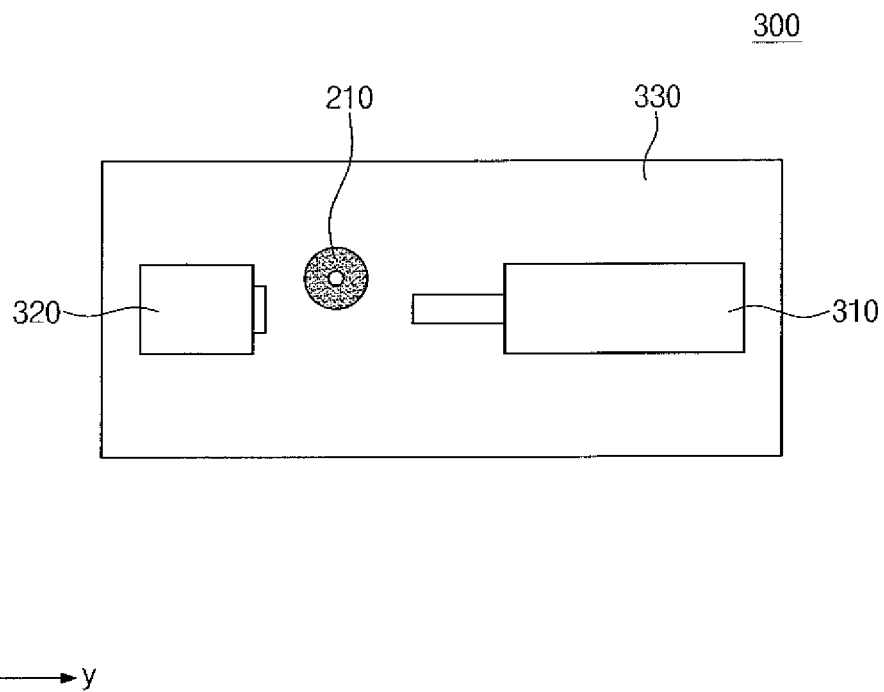


Fig. 5A

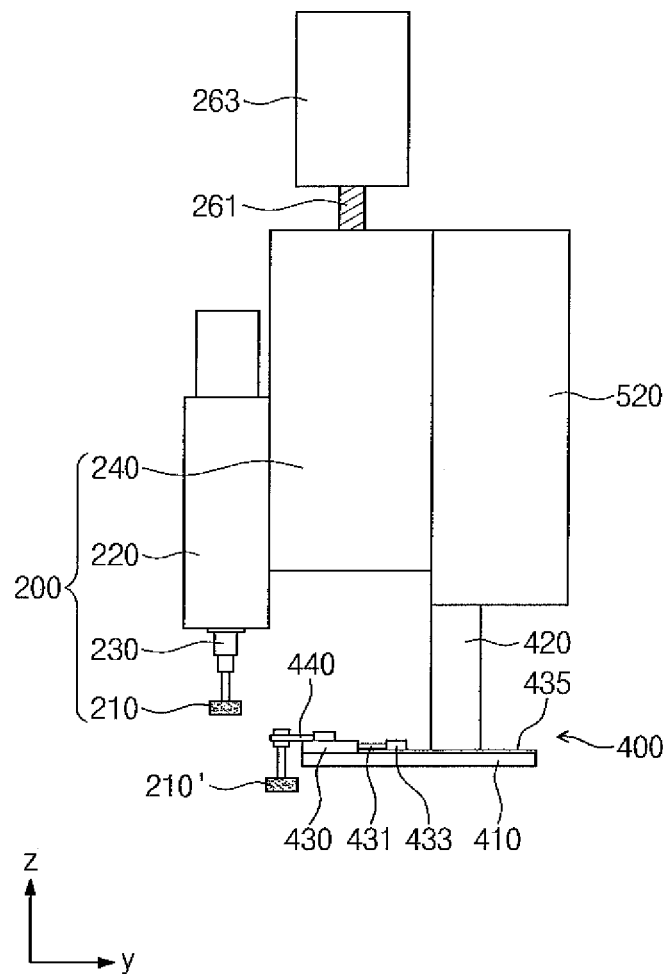


Fig. 5B

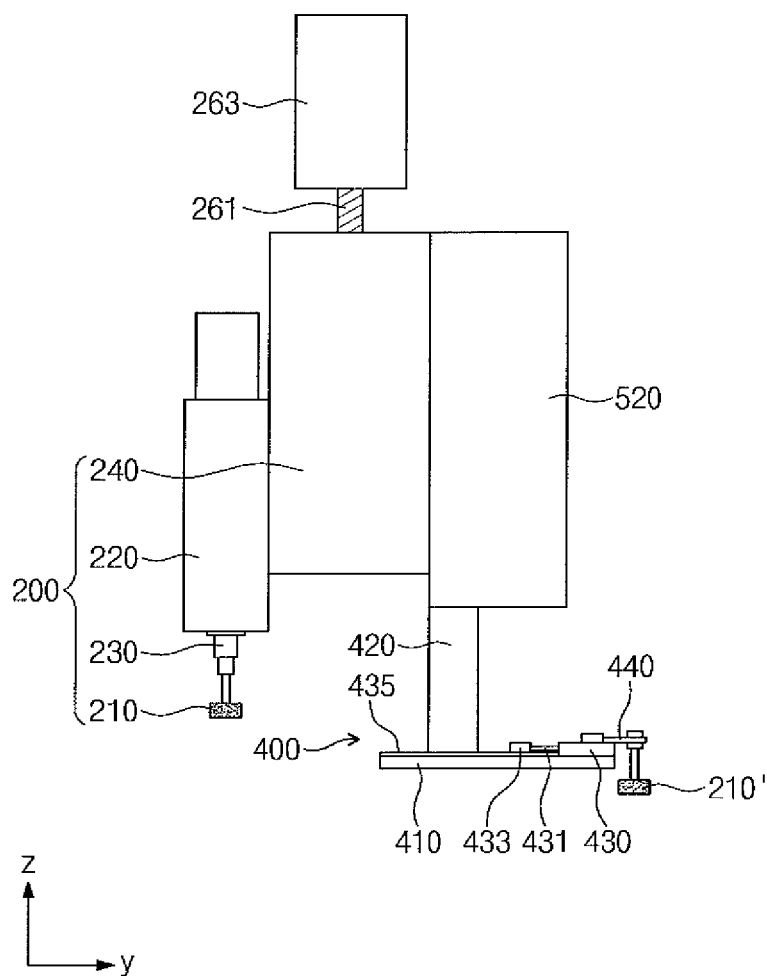




Fig. 6

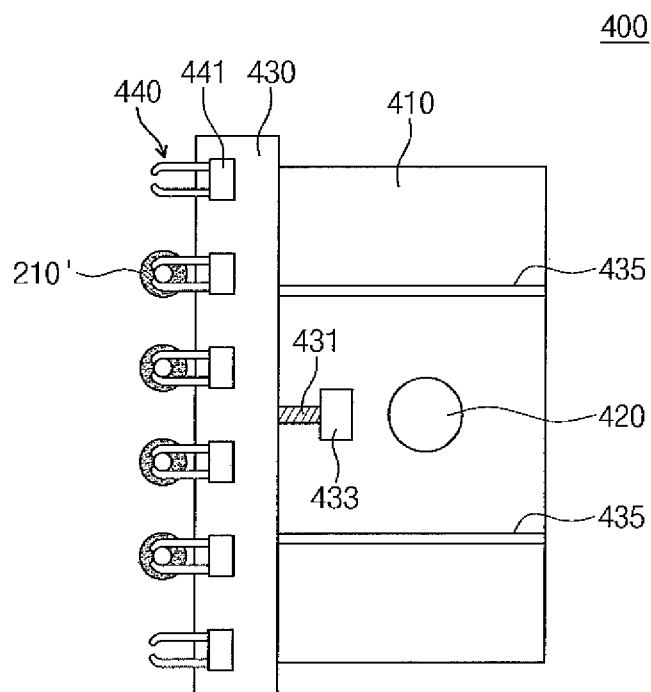
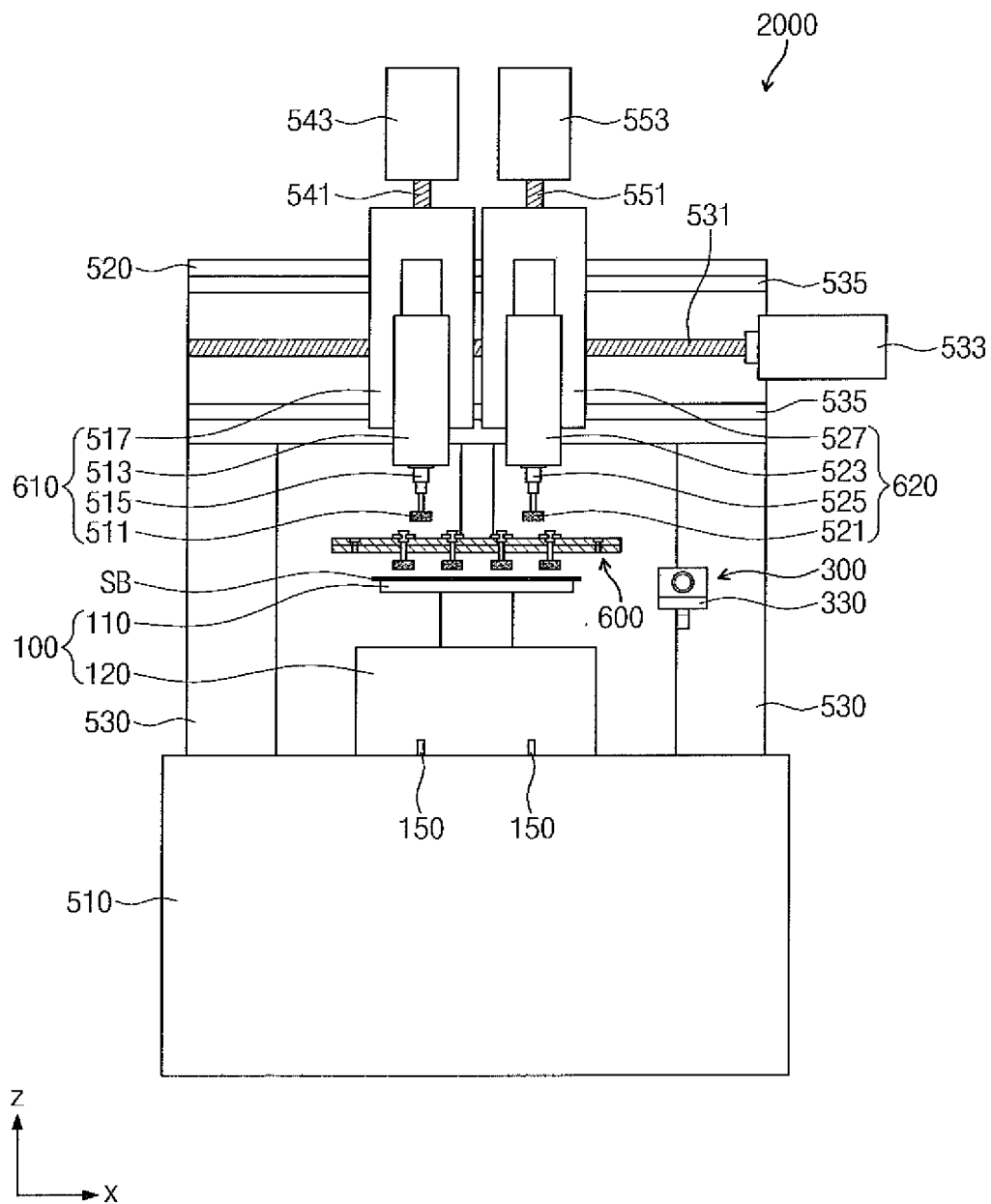


Fig. 7



# APPARATUS FOR GRINDING A SUBSTRATE AND METHOD OF USING THE SAME

## CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority under 35 U.S.C. §119 to Korean Patent Application No. 10-2012-0054443, filed on May 22, 2012, the disclosure of which is hereby incorporated by reference herein in its entirety.

### 1. Technical Field

The present disclosure relates to an apparatus for grinding a substrate and a method of using the same. More particularly, the present disclosure relates to an apparatus for grinding an edge of a substrate and a method of grinding the edge of the substrate using the same.

### 2. Discussion of the Related Art

A display device includes a display panel to display an image, and the display panel includes, for example, a glass substrate or a plastic substrate as its insulating substrate. In addition, a solar cell includes, for example, a tempered glass as its substrate.

To manufacture the display panel or the solar cell, a process for cutting a substrate and a process for grinding an edge of the substrate may be required. The edge indicates, for example, a corner at which a side surface of the substrate meets with an upper or lower surface of the substrate.

A conventional substrate grinding apparatus may include a rough grinding part performing a rough grinding process and a finish grinding part performing a finish grinding process. The rough grinding part and the finish grinding part are coupled with x-axis direction shafts, respectively. However, when the axes of the x-axis direction shafts are twisted, the edge of the substrate may not be uniformly ground.

In addition, whenever the grinding process is performed, a position of the rough grinding part against the substrate or a position of the finish grinding part against substrate may be required to be compensated. As a result, the total time for the grinding process may be lengthened, and thus the yield of the grinding process may be lowered.

## SUMMARY

Exemplary embodiments of the present invention provide an apparatus for grinding a substrate, which is capable of reducing the cost and size of equipment and increasing process efficiency.

Exemplary embodiments of the present invention provide a method of grinding the substrate, which is capable of reducing the cost and size of equipment and increasing process efficiency.

Embodiments of the present invention provide an apparatus for grinding a substrate which includes a stage part configured to support a substrate thereon, a grinding part, a camera part, a replacing part and a control unit. The grinding part includes a grinding wheel configured to grind an edge of the substrate. The camera part is configured to take a picture of the grinding wheel, analyze the picture of the grinding wheel and generate information about the grinding wheel. The replacing part includes a spare grinding wheel which is configured to provide the spare grinding wheel to the grinding part or pick up the grinding wheel from the grinding part. The control unit is configured to receive the grinding wheel information from the camera part and offset compensate a position of the grinding wheel on the basis of the grinding wheel

information or communicate with the replacing part to replace the grinding wheel on the basis of the grinding wheel information.

The grinding wheel includes a rough grinding groove and a finish grinding groove.

The camera part includes a camera and a backlight. The camera is configured to take the picture of the grinding wheel and the backlight is disposed facing the camera and is configured to provide a light to the camera.

The replacing part is configured to be operated in a replacement mode or a standby mode on the basis of the grinding wheel information. The replacing part includes a replacing plate, a replacing table, and a holder. The replacing plate is configured to be rotated with reference to the z-axis as its rotation axis. The replacing table is disposed on the replacing plate and configured to move along the y-axis direction. The holder is disposed on the replacing table and configured to hold the spare grinding wheel.

The replacing plate is configured to be rotated 180 degrees about the z-axis as its rotation axis when the replacement mode is changed to the standby mode.

According to embodiments, the substrate grinding apparatus includes a first grinding part and a second grinding part. The first grinding part includes a rough grinding wheel and the second grinding part includes a finish grinding wheel. The first grinding part and the second grinding part are connected to a same x-axis transfer unit and connected to separate z-axis transfer units.

Embodiments of the present invention provide a method of grinding a substrate. The method includes loading a substrate, taking a picture of a grinding wheel and analyzing the picture of the grinding wheel to generate information about the grinding wheel, checking whether the grinding wheel is required to be replaced or not on the basis of the grinding wheel information, offset compensating a position of the substrate and the grinding wheel on the basis of the grinding wheel information, and grinding an edge of the substrate.

The method further includes replacing the grinding wheel after checking whether the grinding wheel is required to be replaced.

In accordance with an exemplary embodiment of the present invention, an apparatus for grinding a substrate is provided. The apparatus includes a stage part which includes a stage configured to support a substrate thereon and a stage body fixed to the stage, a lower frame supporting the stage part, wherein the stage body is disposed between the stage and the lower frame, a grinding part that includes a grinding wheel configured to grind an edge of the substrate, a spindle operatively connected to the grinding wheel and configured to pivot the grinding wheel along a z-axis direction, a grinding chuck connecting the spindle and the grinding wheel to each other, and a spindle transfer, an x-axis transfer unit configured move in an x-axis direction which is perpendicular to the z-axis direction, wherein the x-axis transfer unit includes an x-axis shaft operatively connected to the spindle transfer, an x-axis motor which is configured to rotate the x-axis shaft, and an x-axis guide rail which is configured to guide movement of the spindle transfer along the x-axis direction.

The apparatus further includes a camera part including a camera configured to take a picture of the grinding wheel, analyze the picture of the grinding wheel and generate information about the grinding wheel, a backlight facing the camera and configured to provide light to the camera, and a camera supporter, wherein the camera and the backlight are spaced apart from each other and are disposed on the camera supporter, a replacing part that includes a spare grinding wheel, wherein the replacing part is configured to provide the

3

spare grinding wheel to the grinding part or pick up the grinding wheel from the grinding part, and a control unit configured to receive the grinding wheel information from the camera part and offset compensate a position of the grinding wheel on the basis of the grinding wheel information or communicate with the replacing part to replace the grinding wheel on the basis of the grinding wheel information.

In addition, the apparatus further includes an upper frame supporting the grinding part and the replacing part and a column frame disposed between the upper frame and the lower frame at a position corresponding to an end portion of the lower frame and the upper frame.

According to the above exemplary embodiments, the number of the grinding parts may be reduced, and thus the cost and size of the substrate grinding apparatus may be reduced. In addition, the rough grinding process and the finish grinding process may be accurately performed by taking the picture of the grinding wheel and adjusting an offset compensation value based upon on the picture of the grinding wheel. Further, the amount of time required for replacing the grinding wheel may be shortened, thereby increasing process efficiency.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Exemplary embodiments of the present invention can be understood in more detail from the following detailed description when taken in conjunction with the accompanying drawings in which:

FIG. 1 is a front view showing a substrate grinding apparatus according to an exemplary embodiment of the present invention;

FIG. 2 is a side view showing the substrate grinding apparatus shown in FIG. 1;

FIG. 3 is a cross-sectional view showing a grinding wheel shown in FIGS. 1 and 2;

FIG. 4 is a plan view showing a camera part shown in FIGS. 1 and 2;

FIG. 5A is a side view showing a grinding part and a replacing part operated in a replacement mode shown in FIG. 2;

FIG. 5B is a side view showing a grinding part and a replacing part operated in a standby mode shown in FIG. 2;

FIG. 6 is a plan view showing a replacing part shown in FIG. 2; and

FIG. 7 is a front view showing a substrate grinding apparatus according to an exemplary embodiment of the present invention.

#### DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

It will be understood that when an element or layer is referred to as being “on”, “connected to” or “coupled to” another element or layer, it can be directly on, connected or coupled to the other element or layer or intervening elements or layers may be present. Like numbers refer to like elements throughout. As used herein, the term “and/or” includes any and all combinations of one or more of the associated listed items.

The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the invention. As used herein, the singular forms, “a”, “an” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise.

4

Hereinafter, exemplary embodiments of the present invention will be explained in detail with reference to the accompanying drawings.

In the description hereinafter, x-, y-, and z-axes mean, for example, directions substantially perpendicular to each other on a three-dimensional space. Accordingly, only two axes among the x-, y-, and z-axes have been shown in figures, and the direction of remaining one axis may be obviously recognized.

In addition, a process space means, for example, a three-dimensional space in which a substrate SB is ground by a grinding part **200** and a stage part **100**.

FIG. 1 is a front view showing a substrate grinding apparatus according to an exemplary embodiment of the present invention and FIG. 2 is a side view showing the substrate grinding apparatus shown in FIG. 1.

Referring to FIGS. 1 and 2, the substrate grinding apparatus **1000** includes, for example, a stage part **100**, a grinding part **200**, a camera part **300**, and a replacing part **400**. The substrate grinding apparatus **1000** may further include, for example, a frame. The frame includes, for example, a lower frame **510**, an upper frame **520**, and a column frame **530**.

The lower frame **510** supports the stage part **100**. The upper frame **520** supports the grinding part **200** and the replacing part **400**. The column frame **530** is located at, for example, a position corresponding to an end portion of the lower frame **510** and the upper frame **520** and the column frame **530** is connected between the lower frame **510** and the upper frame **520**. In FIG. 1, two column frames **530** have been shown but the number and shape of the column frame **530** of exemplary embodiments of the present invention are not limited thereto or thereby. In addition, the lower frame **510**, the upper frame **520**, and the column frame **530** are separated from each other, but exemplary embodiments of the present invention are not be limited thereto or thereby. For example, alternatively in an exemplary embodiment, the lower frame **510**, the upper frame **520**, and the column frame **530** may be integrally formed with each other.

The stage part **100** includes, for example, a stage **110** on which a substrate SB is loaded and a stage body **120**. The substrate SB may be formed of, for example, a transparent insulation material such as glass, quartz, or plastic. Further, in an exemplary embodiment, the transparent glass may include, for example, tempered glass. In an exemplary embodiment, the transparent plastic may be, for example, one of polycarbonate (PC), polyester (PET), polypropylene (PP), polyethylene (PE) and polymethyl methacrylate (PMMA). Alternatively, the substrate SB may instead be formed of a non-transparent material such as, for example, a silicon plate or ceramics.

The stage **110** is fixed to the stage body **120**, and the stage body **120** is disposed between the stage **110** and the lower frame **510**.

The stage body **120** is coupled with, for example, a y-axis transfer unit which moves in a y-axis direction. The y-axis transfer unit includes, for example, a y-axis shaft **130**, a y-axis motor **140**, and a y-axis guide rail **150**.

The y-axis shaft **130** may be, for example, a mechanical actuator such as a ball screw having a ball-shaped thread which is thread-coupled with the stage body **120** but exemplary embodiments are not limited thereto. For example, alternatively, the y-axis shaft **130** may include other mechanical actuators such as a roller screw, a leadscrew, or a screw jack. The y-axis motor **140** rotates the y-axis shaft **130**. The y-axis guide rail **150** guides the movement of the stage body **120**.

5

When the y-axis motor **140** is operated, the stage body **120** moves along the y-axis direction via the y-axis guide rail **150**.

Although not shown in FIGS. **1** and **2**, the substrate grinding apparatus **1000** may further include, for example, a loading part that loads or unloads the substrate SB. The loading part may be disposed, for example, on a path corresponding to the y-axis direction along which the stage body **120** moves. In an exemplary embodiment of the present invention, the loading part may include, for example, a robot arm for loading and unloading the substrate SB.

For example, the stage body **120** moves to the position of the loading part to load the substrate SB before a grinding process is performed or unloads the substrate SB after a grinding process is finished.

The grinding part **200** includes, for example, a grinding wheel **210**, a spindle **220**, a grinding chuck **230**, and a spindle transfer **240**. The grinding part **200** performs, for example, a rough grinding process or a finish grinding process on an edge of the substrate SB.

The grinding wheel **210** grinds a side edge of the substrate SB. The grinding wheel **210** includes, for example, a rough grinding groove and a finish grinding groove. Thus, the grinding wheel **210** may perform both the rough grinding process and the finish grinding process. The shape of the grinding wheel **210** will be described in detail later.

The spindle **220** is equipped with, for example, the grinding wheel **210** to pivot the grinding wheel **210** about the z-axis.

The grinding chuck **230** connects the spindle **220** and the grinding wheel **210**. An upper portion of the grinding chuck **230** is coupled with a lower portion of the spindle **220** and a lower portion of the grinding chuck **230** is coupled with or separated from the grinding wheel **210**. For instance, the grinding chuck **230** is provided with a chuck hole and the grinding wheel **210** is inserted into the chuck hole. Then, the grinding wheel **210** inserted into the chuck hole is fastened or released by, for example, a claw, so the grinding wheel **210** may be coupled with or separated from the grinding chuck **230**.

The spindle transfer **240** is connected with an x-axis transfer unit and a z-axis transfer unit to be transferred in the x-axis direction and the z-axis direction, respectively. The x-axis transfer unit includes, for example, an x-axis shaft **251**, an x-axis motor **253**, and an x-axis guide rail **255**. The z-axis transfer unit includes, for example, a z-axis shaft **261**, a z-axis motor **263**, and a z-axis guide rail (not shown).

The x-axis shaft **251** may be, for example, a mechanical actuator such as a ball screw having a ball-shaped thread which is thread-coupled with the spindle transfer **240** but exemplary embodiments of the present invention are not limited thereto. For example, alternatively, the x-axis shaft **130** may include other mechanical actuators such as a roller screw, a leadscrew, or a screw jack. The x-axis motor **253** rotates the x-axis shaft **251**. The x-axis guide rail **255** guides the movement of the spindle transfer **240** along the x-axis direction.

When the x-axis motor **253** is operated, the spindle transfer **240** moves along the x-axis direction via the x-axis guide rail **255**.

In an exemplary embodiment, the x-axis transfer unit, the y-axis transfer unit and the z-axis transfer unit may be, for example, a conveyor such as a belt conveyor, a live roller belt conveyor, or a chain conveyor.

The grinding wheel **210** grinds the side edge of the substrate SB, which is, for example, substantially in parallel with the x-axis, while the spindle transfer **240** moves along the x-axis direction.

6

In addition, the grinding wheel **210** grinds the side edge of the substrate SB, which is substantially in parallel with the y-axis, while the stage body **120** moves along the y-axis direction.

Consequently, due to the movement of the spindle transfer **240** and the stage body **120**, the side edge of the substrate SB may be ground. In the present exemplary embodiment, the substrate SB has a rectangular flat plate shape, but exemplary embodiments of the present invention are not limited thereto or thereby. That is, as the spindle transfer **240** and the stage body **120** may independently move in the x- and y-axis directions, the side edge of the substrate SB may be ground regardless of whether the shape of the substrate is flat or not.

Similarly, the z-axis shaft **261** may be, for example, a mechanical such as a ball screw having a ball-shaped thread which is thread-coupled with the spindle transfer **240** but exemplary embodiments of the present invention are not limited thereto. For example, alternatively, the z-axis shaft **130** may include other mechanical actuators such as a roller screw, a leadscrew, or a screw jack. The z-axis motor **263** rotates the z-axis shaft **261**. The z-axis guide rail (not shown) guides the movement of the spindle transfer **240** along the z-axis direction.

When the z-axis motor **263** is operated, the spindle transfer **240** moves along the z-axis direction via the z-axis guide rail (not shown).

The y-axis motor **140**, the x-axis motor **253** and the z-axis motor **263** may each include, for example, one of a linear motor, a stepper motor, a servo motor, a direct current (DC) motor, or an alternating current (AC) motor. For example, in an exemplary embodiment, the y-axis motor **140**, the x-axis motor **253** and the z-axis motor **263** may each include a brushed DC servo motor, a brushless AC servo motor, or a brushless DC motor.

Due to the movement of the spindle transfer **240** along the z-axis, a center thickness of the substrate SB may be exactly aligned with a z-axis center of the groove of the grinding wheel **210**.

FIG. **3** is a cross-sectional view showing a grinding wheel shown in FIGS. **1** and **2**.

Referring to FIG. **3**, the grinding wheel **210** includes, for example, the rough grinding groove **211** and the finish grinding groove **213**. FIG. **3** shows two rough grinding grooves **211** and two finish grinding grooves **213**, but the number of the rough and finish grinding grooves **211** and **213** of exemplary embodiments of the present invention are not limited thereto or thereby.

The rough grinding groove **211** has, for example, a depth **d1** smaller than a depth **d2** of the finish grinding groove **213**.

The grinding part **200** performs the rough grinding process on the substrate SB using the rough grinding groove **211**. Then, the grinding part **200** performs the finish grinding process on the substrate SB using the finish grinding groove **213**. The substrate SB is more roughly ground by the rough grinding process than when the substrate SB is ground by the finish grinding process, and the ground amount of the substrate SB in the rough grinding process is significantly more than the ground amount of the substrate SB in the finish grinding process.

In a conventional substrate grinding apparatus, the rough grinding part and the finish grinding part are separated from each other. The rough grinding part and the finish grinding part are coupled with x-axis direction shafts, respectively. Therefore, whenever the grinding process is performed, the position of the rough grinding part and the finish grinding part against the substrate is required to be compensated.

7

However, as described above in exemplary embodiments of the present invention, the substrate grinding apparatus **1000** includes the grinding part **200** that performs the rough grinding process and the finish grinding process and moves along the x-axis direction via the x-axis shaft **251**. Thus, although the position of the x-axis of the grinding part **200** is compensated once, the rough grinding process and the finish grinding process may be exactly performed. In addition, the number of the grinding parts **200** is reduced, so that the equipment for the grinding of the substrate may be significantly reduced in size and cost.

FIG. **4** is a plan view showing the camera part **300** shown in FIGS. **1** and **2**.

Referring to FIGS. **1**, **2**, and **4**, the camera part **300** includes, for example, a camera **310** and a backlight **320**. The camera part **300** further includes, for example, a camera supporter **330** protruded from the column frame **530** to support the camera **300** and the backlight **320**. The camera supporter **330** may have various shapes as long as the camera supporter **330** can securely support the camera **310** and the backlight **320**.

The camera **310** is, for example, spaced apart from the backlight **320** in the y-axis direction to face the backlight **320**.

The camera **300** may be disposed, for example, on a path corresponding to the x-axis along which the grinding part **200** moves. For example, the grinding part **200** moves along the x-axis guide rail **255** to allow the grinding wheel **210** to be located between the camera **310** and the backlight **320**. In this case, the camera **310**, the grinding wheel **210**, and the backlight **320** are sequentially disposed in a straight line substantially in parallel to the y-axis.

For example, the camera **310** takes a picture of the grinding wheel **210** disposed between the camera **310** and the backlight **320** using light emitted from the backlight **320**.

The camera **310** takes, for example, twelve or more sampling images per second and has a resolution to locate fine damages of grooves of the grinding wheel **210**.

Although not shown in FIG. **4**, the camera part **300** may further include, for example, a cleaning part to clean the grinding wheel **210**. The cleaning part sprays air to the grinding wheel **210** when the grinding wheel **210** is disposed between the camera **310** and the backlight **320**, thereby removing foreign substances in the rough grinding groove **211** and the finish grinding groove **213** of the grinding wheel **210**.

Meanwhile, according to the present exemplary embodiment, the grinding part **200** moves in the x-axis direction before performing the rough grinding process to allow the grinding wheel **210** to be located between the camera **310** and the backlight **320**. The camera **310** takes a picture of the grinding wheel **210** and analyzes the picture so as to generate information about the grinding wheel **210**.

Referring to back FIGS. **1** to **4**, the grinding wheel **210** information includes, for example, a position in the z-axis direction of a center line **c1** crossing the rough grinding groove **211**, a degree of slope  $\theta 1$  and  $\theta 2$  of the rough grinding groove **211**, the depth **d1** of the rough grinding groove **211**, a position in the z-axis direction of a center line **c2** crossing the finish grinding groove **213**, a degree of slope  $\Phi 1$  and  $\Phi 2$  of the finish grinding groove **213**, and the depth **d2** of the finish grinding groove **213**.

The substrate grinding apparatus **1000** further includes, for example, a control unit (not shown). The control unit receives the grinding wheel **210** information from the camera part **300**, offset compensates for the positions in the x- and z-axes direction of the grinding part **210** on the basis of the grinding

8

wheel **210** information, and offset compensates the position in the y-axis direction of the stage part **100**.

For example, the position in the z-axis direction of the grinding part **200** may be compensated by comparing the center line **c1** of the rough grinding groove **211** and the center line **c2** of the finish grinding groove **213** at a position in the z-axis direction of the thickness center of the substrate **SB**.

Then, the grinding part **200** may perform the rough grinding process and the finish grinding process on the edge of the substrate **SB**.

In addition, the control unit checks to see if the grinding wheel **210** should be replaced and drives the replacing part **400** when it is determined that the grinding wheel **210** is worn out or damaged. The replacing part **400** will be described in detail later.

According to the present exemplary embodiment, the rough grinding process and the finish grinding process may be precisely performed by, for example, adjusting offset compensation values on the basis of the grinding wheel **210** information.

FIG. **5A** is a side view showing the grinding part and the replacing part operated in a replacement mode shown in FIG. **2**. FIG. **5B** is a side view showing the grinding part and the replacing part operated in a standby mode shown in FIG. **2**, and FIG. **6** is a plan view showing the replacing part shown in FIG. **2**.

Referring to FIGS. **1**, **2**, **5A**, **5B**, and **6**, the replacing part **400** is operated in the replacement mode or the standby mode. The replacing part **400** is coupled with the upper frame **520** and protrudes toward the lower frame **510**.

The replacing part **400** includes, for example, a replacing plate **410**, a rotating unit **420**, a replacing table **430**, and a holder **440**. The replacing part **400** further includes, for example, at least one spare grinding wheel **210'** to replace the grinding wheel **210** that is worn out or damaged. The spare grinding wheel **210'** has, for example, the same structure and function as those of the grinding wheel **210**. The spare grinding wheel **210'** is not used for the grinding process until it replaces the grinding wheel **210** that is worn out or damaged.

The replacing plate **410** has, for example, a flat surface substantially in parallel with the x- and y-axes but exemplary embodiments of the present invention are not limited to the above shape for the replacing plate **410**.

The rotating unit **420** fixes the upper frame **520** and the replacing plate **410** in the z-axis direction. An end portion of the rotating unit **420** is fixed to the lower portion of the upper frame **520** and the other end portion of the rotating unit **420** is rotatably coupled with the replacing plate **410** and penetrates through a surface of the replacing plate **410**.

For example, the rotating unit **420** is rotated with reference to the z-axis as its rotation axis and the replacing plate **410** is rotated substantially parallel with the x- and y-axes in accordance with the rotation of the rotating unit **420**.

The replacing table **430** is disposed on the replacing plate **410**, which is movable. In FIG. **6**, the replacing table **430** has a rectangular shape with short sides and long sides when viewed in a plan view, but exemplary embodiments of the present invention are not limited to the rectangular shape for the replacing table **430**.

The replacing table **430** is coupled with a table transfer unit, and thus the replacing table **430** moves along the y-axis direction. The table transfer unit includes, for example, a shaft **431**, a motor **433**, and a guide rail **435**.

The shaft **431** may be, for example, a mechanical actuator such as a ball screw having a ball-shaped thread which is thread-coupled with the replacing table **430** but exemplary embodiments of the present invention are not limited thereto.

For example, alternatively, shaft **431** may include, for example, other mechanical actuators such as a roller screw, a leadscrew, or a screw jack. The motor **433** rotates the shaft **431**. The guide rail **435** guides the movement of the replacing table **430**.

When the motor **433** is operated, the replacing table **430** moves along the y-axis direction along the guide rail **435**. The motor **433** may include, for example, one of a linear motor, a stepper motor, a servo motor, a direct current (DC) motor, or an alternating current (AC) motor. For example, in an exemplary embodiment, the motor **433** may include a brushed DC servo motor, a brushless AC servo motor, or a brushless DC motor.

The replacing table **430** is located inside the process space during the replacement mode and located outside the process space during the standby mode. When the replacement mode is changed to the standby mode, the replacing plate **410** is rotated with reference to the z-axis as its rotation axis to move the replacing table **430** to the outside of the process space. When the standby mode is changed to the replacement mode, the replacing plate **410** is rotated with reference to the z-axis as its rotation axis to move the replacing table **430** to the inside of the process space.

The holder **440** is disposed on the replacing table **430** to hold the spare grinding wheel **210'**. The holder **440** has, for example, a tong shape and is fixed to the replacing table **430** by a fixing unit **441**.

The holder **440** is, for example, partially protruded to the outside of the replacing table **430** when viewed in a plan view so as to hold the spare grinding wheel **210'**. The spare grinding wheel **210'** may be held by, for example, the holder **440** so as not to overlap with the replacing plate **410** and the replacing table **430**.

The holder **440** may be provided, for example, in a plural number. FIG. 6 shows six holders **440** as an example. In FIG. 6, each of four holders **440** holds the spare grinding wheel **210'** and the remaining two holders **440** are empty.

Meanwhile, the control unit checks whether or not the grinding wheel **210** needs to be replaced on the basis of the grinding wheel **210** information and applies a driving signal to the replacing part **400** when it is determined that the grinding wheel **210** is worn out or damaged.

The replacing part **400** is operated in response to the driving signal from the control unit. When the standby mode is changed to the replacement mode, the replacing plate **410** is rotated, for example, about 180 degrees about the z-axis as its rotation axis to allow the replacing table **430** to be located inside of the process space. For example, the long sides of the replacing table **430** are arranged substantially in parallel with the x-axis and the spare grinding wheels **210'** are arranged substantially in parallel with the x-axis. Then, the replacing table **430** moves, for example, along the y-axis to allow the grinding wheel **210** and the spare grinding wheel **210'** to be located at the same surface in the x-axis direction and the z-axis direction.

The spindle transfer **240** moves in the x-axis direction to locate the grinding wheel **210** at a position corresponding to the holder **440** that is empty. Then, the spindle transfer **240** descends in the x-axis direction and the grinding chuck **230** releases the claw, and thus the worn out or damaged grinding wheel **210** is discharged to the holder **440** that is empty. Next, the spindle transfer **240** ascends in the z-axis direction.

Then, the spindle transfer **240** moves in the x-axis direction to locate the grinding chuck **230** at a position corresponding to the spare grinding wheel **210'** when viewed in a plan view. The spindle transfer **240** descends in the z-axis direction and fastens the grinding chuck **230** so as to allow the spare grind-

ing wheel **210'** to be equipped with the grinding chuck **230**. Then, the spindle transfer **240** ascends in the z-axis direction.

After replacing the grinding wheel **210**, the grinding part **200** moves to the camera part **300** again. The camera part **300** takes a picture of the spare grinding wheel **210'** and analyzes the picture of the spare grinding wheel **210'** to generate the grinding wheel **210** information.

The replacing part **400** is operated in the standby mode after the grinding wheel **210** is replaced. When the replacement mode is changed to the standby mode, the replacing plate **410** is rotated, for example, about 180 degrees about the z-axis as its rotation axis to move the replacing table **430** to the standby position outside the process space. In a case that the replacing table **430** is in the standby position, an operator may provide a new spare grinding wheel **210'** to the holder **440** that is empty or pick up the worn out or damaged grinding wheel **210** from the holder **440**.

In case of the conventional substrate grinding apparatus, when the grinding wheel is worn out or damaged, the operation of the substrate grinding apparatus is stopped to manually replace the worn out or damaged grinding wheel **210**.

However, in the substrate grinding apparatus **1000** according to the present exemplary embodiment, the replacing part **400** is operated in the replacement mode to replace the worn out or damaged grinding wheel **210** with a spare grinding wheel **210'** when the grinding wheel **210** is worn out or damaged, and thus a replacing time for the grinding wheel **210** may be shortened. In addition, as the replacing part **400** moves the replacing table **430** to the outside of the process space so as to provide the spare grinding wheel **210'** or pick up the worn out or damaged grinding wheel **210** after the replacement of the worn out or damaged grinding wheel **210** is completed, the grinding process may be continuously performed in the process space. Therefore, the process efficiency of the substrate grinding apparatus **1000** may be increased.

Hereinafter, a substrate grinding apparatus **2000** according to an exemplary embodiment will be described.

FIG. 7 is a front view showing the substrate grinding apparatus **2000** according to an exemplary embodiment of the present invention.

The substrate grinding apparatus **2000** shown in FIG. 7 has the same configuration and function as those of the substrate grinding apparatus **1000** shown in FIG. 1 except for a grinding part and a replacing part. Thus, detailed descriptions of the same structural and functional elements in FIG. 7 as the grinding apparatus **1000** shown in FIG. 1 will be omitted.

The grinding part includes, for example, a first grinding part **610** and a second grinding part **620**.

For example, the first grinding part **610** performs a rough grinding process and the second grinding part **620** performs a finish grinding process.

The first grinding part **610** includes, for example, a rough grinding wheel **511**, a first spindle **513**, a first grinding chuck **515**, and a first spindle transfer **517**.

The second grinding part **620** includes, for example, a finish grinding wheel **521**, a second spindle **523**, a second grinding chuck **525**, and a second spindle transfer **527**.

The first spindle **513** is equipped with, for example, the rough grinding wheel **511** to pivot the rough grinding wheel **511** about the z-axis.

The second spindle **523** is equipped with, for example, the finish grinding wheel **521** to pivot the finish grinding wheel **521** about the z-axis.

The first grinding chuck **515** connects the first spindle **513** and the rough grinding wheel **511**.

The second grinding chuck **525** connects the second spindle **523** and the finish grinding wheel **521**. The rough

11

grinding wheel **511** includes, for example, a rough grinding groove and the finish grinding wheel **521** includes a finish grinding groove. The rough grinding groove and the finish grinding groove have, for example, the same structure and function as those of the rough grinding groove **211** and the finish grinding groove **213** shown in FIG. 3, and thus detailed descriptions of the rough grinding groove and the finish grinding groove in the present exemplary embodiment will be omitted.

The first spindle transfer **517** is connected to an x-axis transfer unit and a first z-axis transfer unit, so that the first spindle transfer **517** moves in the x-axis direction and the z-axis direction. The x-axis transfer unit includes, for example, an x-axis shaft **531**, an x-axis motor **533**, and an x-axis guide rail **535**. The first z-axis transfer unit includes, for example, a first z-axis shaft **541**, a first z-axis motor **543**, and a first z-axis guide rail (not shown).

The second spindle transfer **527** is connected to the x-axis transfer unit and a second z-axis transfer unit, and thus the second spindle transfer **527** moves in the x-axis direction and the z-axis direction. The second z-axis transfer unit includes, for example, a second z-axis shaft **551**, a second z-axis motor **553**, and a second z-axis guide rail (not shown). The first x-axis motor **533**, the first z-axis motor **543** and the second z-axis motor **553** may each include, for example, one of a linear motor, a stepper motor, a servo motor, a direct current (DC) motor, or an alternating current (AC) motor. For example, in an exemplary embodiment, the first x-axis motor **533**, the first z-axis motor **543** and the second z-axis motor **553** may each include a brushed DC servo motor, a brushless AC servo motor, or a brushless DC motor.

In an exemplary embodiment, the x-axis transfer unit, the first z-axis transfer unit and the second z-axis transfer unit may be, for example, a conveyor such as a belt conveyor, a live roller belt conveyor, or a chain conveyor.

As the first spindle transfer **517** and the second spindle transfer **527** are connected to the x-axis transfer unit, the first spindle transfer **517** and the second spindle transfer **527** may move together with each other along the x-axis direction. Accordingly, the first spindle transfer **517** and the second spindle transfer **527** may not be dislocated from each other when the first spindle transfer **517** and the second spindle transfer **527** move in the x-axis direction as the first spindle transfer **517** and the second spindle transfer **527** are commonly connected to the x-axis guide rail **535**.

On the other hand, the first spindle transfer **517** and the second spindle transfer **527** are connected to the first z-axis transfer unit and the second z-axis transfer unit, respectively, and thus the first spindle transfer **517** and the second spindle transfer **527** may independently move in the z-axis direction.

According to the present exemplary embodiment, the second spindle transfer **527** ascends along the z-axis direction and maintains a standby state while the first grinding part **610** performs the rough grinding process on the substrate SB. The substrate SB may be formed of, for example, a transparent insulation material such as glass, quartz, or plastic. Further, in an exemplary embodiment, the transparent glass may include, for example, tempered glass. Further, in an exemplary embodiment, the transparent plastic may be, for example, one of polycarbonate (PC), polyester (PET), polypropylene (PP), polyethylene (PE) and polymethyl methacrylate (PMMA). Alternatively, the substrate SB may instead be formed of a non-transparent material such as, for example, a silicon plate or ceramics.

After the rough grinding process is finished, the second spindle transfer **527** descends along the z-axis direction and the second grinding part **620** performs the finish grinding

12

process on the substrate SB. In this case, the first spindle transfer **517** ascends along the z-axis direction and maintains the standby state.

The replacing part **600** has, for example, the substantially same configuration as that of the replacing part **400** shown in FIG. 1. The replacing part **600** includes, for example, at least one spare grinding wheel. The spare grinding wheel may be, for example, the rough grinding wheel or the finish grinding wheel.

An abrasion loss of the substrate SB in the rough grinding process may be greater than that of the substrate SB in the finish grinding process, so the rate of abrasion of the rough grinding groove of the rough grinding wheel **511** may be greater than that of the finish grinding groove of the finish grinding wheel **521**. Thus, the life-span of the rough grinding wheel **511** may be shorter than the life-span of the finish grinding wheel **521**.

According to the present exemplary embodiment, the rough grinding wheel **511** and the finish grinding wheel **521** may be separately replaced by the replacing part **600**, so that the number of the grinding wheels required to grind the substrate SB may be reduced, thereby reducing the cost of grinding the substrate SB.

Having described exemplary embodiments of the present invention, it is further noted that it is readily apparent to those of ordinary skill in the art that various modifications may be made without departing from the spirit and scope of the invention which is defined by the metes and bounds of the appended claims.

What is claimed is:

1. An apparatus for grinding a substrate, comprising:

a stage part configured to support a substrate thereon;  
a grinding part that includes a grinding wheel configured to grind an edge of the substrate;

a camera part configured to take a picture of the grinding wheel, analyze the picture of the grinding wheel and generate information about the grinding wheel;

a replacing part that includes a spare grinding wheel and a replacing table, wherein the replacing part is configured to provide the spare grinding wheel to the grinding part or pick up the grinding wheel from the grinding part and the replacing table is configured such that the replacing table is disposed inside a process space, in which the substrate is ground, during a replacement mode and disposed outside the process space during a standby mode such that the spare grinding wheel can be provided prior to being picked up and the grinding wheel may be removed after being picked up from the grinding part without stopping the operation of the substrate grinding apparatus; and

a control unit configured to receive the grinding wheel information from the camera part and offset compensate a position of the grinding wheel on the basis of the grinding wheel information or communicate with the replacing part to replace the grinding wheel on the basis of the grinding wheel information.

2. The apparatus of claim 1, wherein the stage part is configured to move along a y-axis direction and the grinding part is configured to move along an x-axis direction and a z-axis direction.

3. The apparatus of claim 1, wherein the grinding part is connected to one x-axis transfer unit.

4. The apparatus of claim 3, wherein each of the grinding wheel and the spare grinding wheel comprises a rough grinding groove and a finish grinding groove.

5. The apparatus of claim 1, wherein the camera part comprises:



## 13

a camera that is configured to take the picture of the grinding wheel; and  
 a backlight disposed facing the camera and configured to provide a light to the camera.

6. The apparatus of claim 5, wherein the camera, the grinding wheel, and the backlight are sequentially disposed in a straight line substantially parallel to the y-axis.

7. The apparatus of claim 1, wherein the replacing part is configured to be operated in the replacement mode or the standby mode on the basis of the grinding wheel information.

8. The apparatus of claim 7, wherein the replacing part further comprises:

a replacing plate configured to be rotated with reference to a z-axis as its rotation axis; and

a holder disposed on the replacing table and configured to hold the spare grinding wheel,

wherein the replacing table is disposed on the replacing plate and configured to move along a y-axis direction.

9. The apparatus of claim 8, wherein the replacing plate is configured to be rotated about 180 degrees about the z-axis as its rotation axis when the replacement mode is changed to the standby mode.

10. The apparatus of claim 1, wherein the grinding part comprises:

a first grinding part that includes a rough grinding wheel; and

a second grinding part that includes a finish grinding wheel.

11. The apparatus of claim 10, wherein the first grinding part and the second grinding part are connected to a same x-axis transfer unit.

12. The apparatus of claim 11, wherein the first grinding part and the second grinding part are connected to separate z-axis transfer units.

13. A method of grinding a substrate, comprising:

loading a substrate into a process space;

grinding an edge of the substrate within the process space using a grinding wheel held by a grinding part;

taking a picture of the grinding wheel and analyzing the picture of the grinding wheel to generate information about the grinding wheel;

checking whether the grinding wheel is required to be replaced or not on the basis of the grinding wheel information; and

performing replacement mode steps when it is determined that the grinding wheel is required to be replaced, wherein the replacement mode steps include:

moving a replacement table carrying a replacement grinding wheel from outside the process space into the process space;

discharging the grinding wheel and installing the replacement grinding wheel such that the replacement grinding wheel is on the grinding part and the grinding wheel is on the replacement table; and

moving the replacement table carrying the grinding wheel from inside the process space to outside the process space, and

wherein the performance of the replacement mode steps occurs without stopping the operation of the substrate grinding apparatus.

14. An apparatus for grinding a substrate, comprising:

a stage part which includes a stage configured to support a substrate thereon and a stage body fixed to the stage;

a lower frame supporting the stage part, wherein the stage body is disposed between the stage and the lower frame;

a grinding part that includes a grinding wheel configured to grind an edge of the substrate, a spindle operatively

## 14

connected to the grinding wheel and configured to pivot the grinding wheel along a z-axis direction, a grinding chuck connecting the spindle and the grinding wheel to each other, and a spindle transfer;

an x-axis transfer unit configured move in an x-axis direction which is perpendicular to the z-axis direction, wherein the x-axis transfer unit includes an x-axis shaft operatively connected to the spindle transfer, an x-axis motor which is configured to rotate the x-axis shaft, and an x-axis guide rail which is configured to guide movement of the spindle transfer along the x-axis direction;

a camera part including a camera configured to take a picture of the grinding wheel, analyze the picture of the grinding wheel and generate information about the grinding wheel, a backlight facing the camera and configured to provide light to the camera, and a camera supporter, wherein the camera and the backlight are spaced apart from each other and are disposed on the camera supporter;

a replacing part that includes a spare grinding wheel and a replacing table, wherein the replacing part is configured to provide the spare grinding wheel to the grinding part or pick up the grinding wheel from the grinding part and the replacing table is configured such that the replacing table is disposed inside a process space, in which the substrate is ground, during a replacement mode and disposed outside the process space during a standby mode such that the spare grinding wheel can be provided prior to being picked up and the grinding wheel may be removed after being picked up from the grinding part without stopping the operation of the substrate grinding apparatus;

a control unit configured to receive the grinding wheel information from the camera part and offset compensate a position of the grinding wheel on the basis of the grinding wheel information or communicate with the replacing part to replace the grinding wheel on the basis of the grinding wheel information;

an upper frame supporting the grinding part and the replacing part; and

a column frame disposed between the upper frame and the lower frame at a position corresponding to an end portion of the lower frame and the upper frame.

15. The apparatus of claim 14, further comprising a z-axis transfer unit configured to move in the z-axis direction, wherein the z-axis transfer unit includes a z-axis shaft operatively connected to the spindle transfer, a z-axis motor which is configured to rotate the z-axis shaft, and a z-axis guide rail which is configured to guide movement of the spindle transfer along the z-axis direction.

16. The apparatus of claim 15, further comprising a y-axis transfer unit configured to move in a y-axis direction which is perpendicular to the z-axis direction, wherein the y-axis transfer unit includes a y-axis shaft operatively connected to the stage body, a y-axis motor which is configured to rotate the y-axis shaft, and a y-axis guide rail which is configured to guide movement of the stage body along the y-axis direction.

17. The apparatus of claim 15, wherein at least one of the x-axis shaft or the z-axis shaft includes a ball screw having a ball shaped thread which is coupled to the spindle transfer.

18. The apparatus of claim 14, wherein each of the grinding wheel and the spare grinding wheel comprise a rough grinding groove and a finish grinding groove, wherein the rough grinding groove has a depth smaller than a depth of the finish grinding groove.

19. The apparatus of claim 14, wherein an upper portion of the grinding chuck is coupled with a lower portion of the

15

spindle and a lower portion of the grinding chuck is removably coupled with the grinding wheel.

20. The apparatus of claim 14, wherein the camera supporter protrudes from the column frame to support the camera and the backlight.

5

21. The apparatus of claim 16, wherein the replacing part comprises:

a replacing plate having a substantially flat surface parallel with the x-axis direction and the y-axis direction;

a rotating unit configured to fix the upper frame and the replacing part in the z-axis direction and wherein the rotating unit is configured to rotate with reference to the z-axis direction as its rotating axis and to rotate the replacing plate in a direction substantially parallel to the x-axis direction and the y-axis direction; and

15

a holder disposed on the replacing table and configured to hold the spare grinding wheel,

wherein the replacing table is disposed on the replacing plate and configured to move along a y-axis direction.

22. The apparatus of claim 18, wherein the grinding wheel information comprises a position in the z-axis direction of a center line crossing the rough grinding groove, a degree of slope of the rough grinding groove, the depth of the rough grinding groove, a position in the z-axis direction of a center line crossing the finish grinding groove, a degree of slope of the finish grinding groove, and the depth of the finish grinding groove.

20

25

\* \* \* \* \*

16